the blood. This wet line undoubtedly gives, independently of the purification of the air by the spray, an additional and important degree of protection, and here we observe the fact that all experimentation with the spray on putrescible fluids must fail to give similar results to those which we obtain in our practice of antiseptic surgery. The wet-line protection must be given a still wider scope. It must be even extended to the instruments employed by the surgeon, his hands, and likewise his clothing, as well as to all other surrounding objects in which the germs find a temporary lodgment, but from which they are liable to be transferred to the wound.

The highly satisfactory and almost perfect results obtained by the strict adherents to Lister's system of wound-treatment justifies the conclusion that the spray and other protective measures practised by this distinguished surgeon are a complete prophylaxis of putrefaction where properly employed; and the results of our experiments are confirmatory of this opinion. Furthermore, we are convinced that the use of the spray is an essential part of this system, and that no substitute has yet been offered which gives the same degree of protection.

ARTICLE XII.

ON THE STATE OF THE BLOOD IN THE VESSELS OF AN INFLAMED PART.

By THOMAS WHARTON JONES, F.R.S., F.R.C.S., Professor of Ophthalmic Medicine and Surgery in University College, London; Ophthalmic Surgeon to the Hospital, etc.

THE redness of blushing, with accompanying heat (see the second part of my Discourse on the circulation of the blood in its bearings on Practical Medicine and Surgery, in the *Lancet*, vol. ii., for 1879), is owing to an increased afflux of blood to the face permitted by sudden dilatation of the small arteries. The paleness, with coldness, on the contrary, which may immediately precede blushing with heat, is owing to diminished access of blood to the face occasioned by constriction of the same vessels. This constriction of small arteries is owing to contraction of their muscular walls excited by some transient general nervous impression or emotion operating through the vaso-motor nerves. The action of the vaso-motor nerves now remitting, the contraction of the arterial walls gives place to relaxation, so that dilatation succeeds constriction of calibre, and the increased afflux of blood is thereby permitted.

The general nervous impression or emotion having exhausted its influence on the vaso-motor nerves of the part, the small arteries resume their ordinary width, and so, the circulation proceeding as before, the face regains its natural hue and temperature.

Phenomena similar to those of blushing may be observed very distinctly in the ear of the white rabbit. From being blanched and cold, the ear becomes red and warm again, at intervals of from a quarter to half a minute. Watching, we can see that the paleness and coldness of the ear are coincident with arrestment of the access of the blood in consequence of constriction of the large artery, whilst the succeeding redness and heat are owing to the free afflux of blood permitted by the dilatation of the artery which supervenes.

The flow of blood, it is to be particularly remarked, is not arrested merely by the constriction of the artery, *but the stream is actually pressed backwards;* the constriction of the artery being regressive *from branches to trunk*, and not contrariwise, as has been erroneously supposed. This may be observed in the frog's web or bat's wing, under the microscope, in a similar crisis of the circulation in those animals.

The redness of inflammation, at the same time that it is not transient like the redness of blushing, is more intense and the state of the blood in the vessels of the inflamed part is different.

In investigating the state of the blood in the vessels of an inflamed part, we have to depend on observations made on the web of the bat's wing or frog's foot, disposed under the microscope.

It is to be premised that, in a small drop of bat's blood drawn from the living animal and forthwith examined under the microscope, the corpuscles are seen to be similar to those of human blood, only somewhat smaller. The red corpuscles agglomerate together into rouleaux in the same manner.

The bat is the only mammiferous animal in which we can watch *satisfactorily*, under the microscope, the state of the blood circulating in the vessels, *not only for a length of time*, but also *time after time.* And what we thus see we may take as indicative of the state of the blood in the minute vessels of man. The state of the blood in the vessels of an *inflamed part of the bat's wing* we may in like manner accept as indicating in all essential particulars the state of the blood in the vessels of an *inflamed part of the human body.* Furthermore, as the state of the blood in the vessels of an inflamed web of the frog, observed under the microscope, is similar to that of the blood in the vessels of an inflamed part of the bat's wing, we may also accept observations made on the frog's web as sufficiently indicative of the state of the blood in the vessels of an inflamed part in man.

The state of the blood in the vessels of an inflamed part, I have said, is different from what it is in blushing. The greater intensity of the external redness is owing to injection of the vessels with *red corpuscles aggregated together to the exclusion of plasma* from among them. This we can see directly, under the microscope, both in the bat and in the frog; and there can be no doubt that what we can see with the help of a magnifying glass in the inflamed conjunctiva of man is indicative of a similar injection of the vessels with red corpuscles to the exclusion of plasma.

I have said that in blushing the arteries are dilated, and that the flow of blood not only in them but also in the capillaries and venous radicles is fuller and freer, so that the redness is owing simply to the greater quantity of blood, *comprising both corpuscles and plasma*, passing through the vessels. That the red blush of the skin is produced by a fuller and freer flow of blood comprising both corpuscles and plasma in the normal porportion may be demonstrated by the experiment of dividing the ischiatic nerve in a frog. The effect visible to the naked eye is that the skin of the leg operated on becomes redder than it was before, and redder than the opposite sound leg. This increased redness we find by microscopical examination to be owing to a fuller and freer flow of blood in the vessels in consequence of dilatation of the arteries from relaxation of their walls induced by the section of the vaso-motor nervous fibrils included in the division of the ischiatic.

It will be seen that in this experiment on the frog we have a microscopical exhibition of the actual state of the blood and the bloodvessels, whereas, in the analogous experiment of cutting the sympathetic nerve in the neck of a rabbit, we obtain only the general manifestation, to the naked eye, of continued vascular fulness in the ear. This vascular fulness is commonly put down as a manifestation of paralytic relaxation of the walls of capillaries and veins, as well as of arteries; but in the experiment on the frog we can see that it is the artery alone which has been affected by the section. Its walls being relaxed, its calibre has become dilated, and the capillaries and veins distended in consequence of the freer afflux of blood to them.

To return to the state of the blood in the vessels of an inflamed part. In an inflamed part of the web of the bat's wing or frog's foot, viewed under the microscope, we see that the red corpuscles are aggregated so closely together as to form a viscid tenacious-looking mass, which flows sluggishly or is actually stagnant within the vessels, injecting them as with a red injection.

The conditions under which the aggregation of red corpuscles takes place within the vessels will be explained below, but here it may be mentioned that the mode in which the corpuscles are seen, under the microscope, to aggregate is similar to that already described in the case of a drop of blood drawn from the body, and especially a drop of blood drawn from a person labouring under some acute inflammation with fever in which there is an increase of the fibrinous constituent of the plasma. In the vessels in which the blood may be still flowing, though sluggishly, the colourless corpuscles are seen accumulated in quantity on the inside of the walls of the vessels; but, in those in which the flow of blood is actually arrested, the colourless corpuscles are mixed up in the agglomerated and stagnant mass of red corpuscles.

In traumatic inflammation, as may be seen in the web of the bat's wing or frog's foot, vascular injection of the part is, in the first instance, produced by regurgitation of blood into venous radicles, capillaries, and extreme arterial ramifications to which the arteries implicated in the wound directly led,[1] but into which, of course, they no longer transmit blood. The regurgitation by which the venous radicles, capillaries, and extreme arterial ramifications are filled with blood takes place from such adjacent anastomosing vessels as receive their supply from unimplicated arterial branches which have their origin above the wound, and in which the blood is still flowing freely as yet.

The red corpuscles of the blood which thus become accumulated in the vessels of the wounded part aggregate together to the exclusion of the plasma; and it is in this manner that the congestion and stagnation of red corpuscles in the vessels[2] are brought about which occasion the redness by which the inflammation arising from the injury is first manifested.

Subsequently the vascular injection becomes increased and extended by accumulation and retention of more corpuscles received from the stream of blood in the uninjured arteries leading to the region of the wound. A more rapid supervention of this result may be demonstrated in the frog by cutting the ischiatic nerve. Owing to the dilatation of the arteries of the web generally thereby induced, and the consequent freer flow of blood in them, corpuscles in greater quantity make their way into the vessels in the region of the wound and there agglomerate.

A still greater increase and extension of the vascular injection in such a case may be demonstrated in another way, viz., by applying a solution of salt to the wounded web. Though this causes increased injection of all the vessels, we observe by careful watching under the microscope that the injection is greatest in the vessels of the injured part, because the blood forced into them by regurgitation is there retained, and stasis of the aggregated red corpuscles occurs more quickly.

In my essay on the state of the blood and the bloodvessels in inflammation, I relate at page 20, that in the frog's web, the arteries were sometimes found much constricted, in which case I observed that the direct flow of blood to their ultimate ramifications and to the capillaries was arrested, and that as long as this constriction persisted blood was seen to regurgitate from the neighbouring anastomosing and still open arteries, and from veins through the capillaries into the terminal ramifications of the constricted arteries. I also observed that the red corpuscles of the regurgitating and slowly moving blood became aggregated together, and that in some places stasis of the aggregated corpuscles took place. Such is the state of the blood in the vessels of a part at the very commencement of an inflammation excited by cold, for example. That the vascular injection is owing to the constriction of the arteries arresting the direct flow of blood is demonstrated by the dispersion of the accumulated corpuscles which take place if the arteries become dilated so that a full and free stream of blood in them is permitted. If such dilatation of the arteries does not spontaneously occur, we can bring it about by applying to the affected web a drop of some irritating fluid, such as spirit of wine. The first effect of this application is increased constriction of the arteries, but the constriction is soon superseded by full dilatation, whereupon a rapid stream of blood in them ensues, so that the accumulated corpuscles in the extreme arterial ramifications, capillaries, and venous radicles are driven onwards. Dilatation of the arteries, with acceleration of the flow of blood in them, and consequent similar dispersion of the congestion, I have found to be an effect of section of the ischiatic nerve.

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[1] See figure of this in Plate VIII. of my Essay in "Guy's Hospital Reports" for October, 1850. I have before me an original drawing of the same thing in the bat.

[2] I have before me a drawing representing this in a vein of the bat's wing which I made from the life.

In reference to all this, however, it is to be remembered that as above pointed out, *vascular injection brought on by a wound implicating arteries*, so far from being dispersed, is increased by such treatment, because the flow of blood in the divided arteries cannot, of course, be restored in the same manner.

A conjunctivitis in the human eye may, at the commencement, present itself as a small spot of vascular injection. On examining such a spot with a magnifying glass, we observe that the arteries are constricted, and that it is their extreme ramifications, the capillaries, and venous radicles, which appear to be injected to distension with red blood.

I have before said that vascular injection of the inflamed conjunctiva in man, as observed by the help of a magnifying glass, resembles the vascular injection in inflammation of the web of the bat's wing or frog's foot, as observed by the same means. For this reason, and knowing that the red corpuscles of human blood out of the body aggregate together like those of the bat's blood, and much more closely than those of frog's blood, we may fairly conclude that in the injected vessels of an inflamed conjunctiva, the corpuscles of the blood are accumulated and aggregated together in a manner similar to that in which we can directly see them in the vessels of the web of the bat or frog under the microscope.

In explanation of the *commencement of a catarrhal inflammation* of the conjunctiva, it is to be remembered that cold excites the vital contraction of the walls of the small arteries of a part with consequent constriction of their calibre. Now we have seen in the web of a frog under the microscope that when some of the arteries were persistently constricted, there took place from adjacent vessels in which the circulation was still free, regurgitation of blood loaded with red corpuscles into those venous radicles and capillaries to which the constricted arteries led, and thence in a retrograde course into the extreme ramifications of those constricted arteries themselves. We have also seen that the flow of this regurgitating blood, loaded with red corpuscles, was sluggish, and that here and there stasis of it within the vessels presented itself.

Such a state of blood, and bloodvessels as that here described, is the *only possible condition which can be conceived* as the first step to inflammatory congestion of the conjunctiva or other part in man from the impression of cold.

The first step to the vascular injection of the conjunctiva, caused by the irritation of a foreign particle in the eye, is in like manner constriction of the small arteries in consequence of the contraction of their muscular walls, excited by the impression made on the vaso-motor nerves either directly or by reflex action. And so again, also, the first step to the inflammatory congestion of a part of the human body—the bronchi for example—caused by the general impression of cold on the whole system is constriction of the small arteries excited by reflex action from the skin to the nervous centre, and thence to the nerves of the arterial walls.

The arteries leading to an inflamed part are, or become, much relaxed and dilated. In consequence of this, the supervening acceleration of the flow of blood in them may, as we have seen, disperse the congestion and stagnation in the extreme arterial ramifications, capillaries, and venous radicles, in which case resolution of the inflammation ensues. But should resolution fail to be accomplished, the dilatation of the arteries only leads to extension of the inflammation by allowing a greater quantity of blood to be poured into the vessels of the affected part than can escape in consequence of the pre-existing and persistent obstruction from stasis. An analogous phenomenon can, as already mentioned, be directly observed in inflammation of the frog's web from a wound.

The phenomena of inflammation affecting some external part of the body, which, from its size, may be conveniently made the subject of observation, have been correctly adduced as indicating that an increased quantity of blood enters the inflamed part, and circulates through it. The phenomena referred to, however, do not warrant the inference that there cannot be stasis of blood in vessels of the affected part. The part which is the actual focus of the inflammatory process is to be distinguished from the surrounding part, as for example, the deep red spot of vascular injection in pustular ophthalmia, surrounded by a blush arising from the free circulation in the neighbouring dilated vessels. It is into and within the latter that a greater quantity of blood circulates, and this because the arteries leading to and distributed in them are, as before mentioned, relaxed and dilated.

In frogs' webs, inflamed from the action of a strong solution of salt in such a degree that a part had sloughed, I sometimes found walls of veins gone. On the sides of such venous channels, destitute of walls, numerous colourless corpuscles were seen accumulated, whilst the blood was flowing freely in the middle. In a case in which the second web had sloughed away to a small piece, stagnation of blood still existed at the edge of that piece; but higher up a free flow of blood had now superseded stagnation in the vessels. Here walls of many of the vessels could no longer be distinguished to exist, and the blood appeared to be flowing in mere passages hollowed out in the substance of the web. All along the sides of the passages numerous blood corpuscles were collected; many of them red corpuscles which had become pale, distended, and of a round shape. In the portion of the web under notice, spots of extravasated blood were seen here and there.

While inflammatory congestion is taking place, and also when stasis has become established, the blood undergoes various alterations. At the very commencement we have seen how the accumulation and aggregation of the red corpuscles, to the exclusion of the plasma, constitutes an important step in the process on which the congestion depends. Then, again, as to the disposal of the excluded plasma: with the establishment of the inflammatory congestion, exudation of certain of the constituents of the plasma takes place through the walls of the vessels. Thus in the early stage, water with salts in solution, is transuded, and in consequence of the inspissation of the plasma thereby induced, the red corpuscles of the blood become more closely aggregated, and the congestion with stasis more fully established. This is illustrated by the exosmotic abstraction of water from the blood caused by the application of salt to the frog's web for the purpose of exciting inflammation; an application which I have also employed for the purpose of making preparations of the frog's web, in different stages of inflammation, by injecting the vessels with their own blood; for this latter purpose the following was the method of proceeding.[1] The foot of a frog being stretched and disposed under the microscope, a saturated solution of common salt was applied to both the dorsal and plantar surfaces of the webs. The salt at first excited constriction of the arteries, but their dilatation quickly supervening, acceleration of the flow of blood in those vessels took place. But the plasma of the blood becoming inspissated by the exosmotic action of the strong salt solution, withdrawing the weaker saline solution from the blood, the red corpuscles aggregated together so as to form a thick viscid mass, which became stagnant in the vessels, filling them like a red injection. The extreme arterial ramifications, the capillaries and veins, it is to be remarked, are, by this process, more fully injected than the trunk of the artery leading to them. The cause of this peculiarity is, that the blood in the larger arteries, flowing with greater force and rapidity, more readily escapes the exosmotic action of the salt; and that when the blood has become stagnant in the extreme arterial ramifications, capillaries, and veins, so as to block them up, the stream in the arterial trunk leading to a given congested spot passes off by some considerable branch above, just as in the case before mentioned, of an artery which has been cut. In the trunk of the artery below the branch by which the stream referred to passes off, down to where stagnation has taken place in it, there may be seen a collection of plasma with only few corpuscles suspended in it, oscillating up and down. This collection of plasma and corpuscles is identical in signification with the so-called internal clot within a divided or ligatured artery.

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[1] See my Essay in "Guy's Hospital Reports," before cited, p. 95.

After exudation of the watery and saline part of the blood, exudation of the fibrinous constituents, in the form of coagulating lymph, takes place.

In explanation of the process of the transudation of the watery and saline part of the blood from the interior of the vessels through their walls, it has been found that saline solutions pass more readily through animal membranes than albuminous solutions. Again, in explanation of the process of exudation of lymph subsequently, it was pointed out by the late Professor Graham, that albuminous matters, when deprived of the salts which always exist mixed with them, are rendered much more diffusible than before.

In inflammation the saline transudation, which takes place first, thus no doubt paves the way for the exudation of lymph which takes place subsequently.

The frog's web, in a state of inflammation, is opaque where stasis has become established, whereas it is unchanged in respect to transparency at the places in which the circulation is still going on freely. As opacity depends on lymph exudation, it thus appears that stasis is a condition on which lymph exudation depends.[1]

The cornea is pervaded with sensitive nerve fibrils derived from the fifth, which have, among other reflex connections, one with the vaso-motor nerves of the arteries of the adjacent conjunctiva and sclerotica. Hence the inflammatory congestion of the conjunctiva and sclerotica which so quickly supervenes on an injury of the cornea. The cornea being non-vascular, congestion does not take place in it. In the course of a keratitis, the cornea, however, may become vascular, owing to the development of new vessels in it in continuity with those of the adjacent part of the conjunctiva and sclerotica; but this morbid vascularity is not a necessary condition, for the cornea may be the seat of exudation only, the congestion on which the exudation of lymph depends being still confined to the adjacent conjunctiva and sclerotica; while in the healing process we may find non-vascular granulations filling up an ulcer, and this followed by cicatrization.

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[1] See Lecture on "Abrasion of the Cornea," in the *Lancet* for January 18, 1879.

As, when the cornea is inflamed, inflammatory congestion of the conjunctiva and sclerotica takes place, so in like manner, when an interstitial morbid process commences idiopathically, congestion of the white of the eye next the affected part of the cornea shows itself. This is owing to reflexion of the irritation of the sensitive corneal nerves to the vaso-motor nerves of the arteries of the adjacent conjunctiva and sclerotica. These arteries thereby become constricted, and inflammatory congestion takes place in the manner before explained.

ARTICLE XIII.

A CONTRIBUTION TO THE CLINICAL HISTORY OF MYOPIA.

By S. D. RISLEY, M.D., Lecturer on Ophthalmoscopy in the University of Pennsylvania; Ophthalmic and Aural Surgeon to the Episcopal Hospital at Philadelphia.

IN the domain of ophthalmology no malady is of greater interest to the surgeon, or of graver import to every civilized community than that of *progressive myopia.* The extreme frequency of its occurrence; the known fact of its acquisition during early life; and its apparently intimate relation to the educational process, have, together with the uncertainty which still hovers over its clinical history, served to elevate it to a first place among the many vexed problems presented to the ophthalmic surgeon for solution. Its great importance has led to the most extended observation and careful collection of statistical information, in the hope that by this means the causes of its production might be discerned and removed.

As early as 1813, James Ware published in the *Philosophical Transactions* his results from the examination of the eyes of 10,000 soldiers. He was followed by numerous other observers, until, in 1876, no less than 52,478 persons had been examined by foreign observers (Emmert). To this large number are to be added the labours of Drs. Derby, Loring, Cheatham, Williams, Prout, and Matthewson, and my own as yet unpublished statistics, in this country. By these extended observations it has been shown conclusively that the percentage of myopia steadily increased from the lower to the higher classes. Thus, in St. Petersburg, Professor Erismann found in 4358 scholars, 13.6 per cent. of myopia in the primary, which had increased to 42.8 per cent. in the higher classes. In Germany the rise was from 11.1 per cent. to 62.1 per cent. The American statistics already published furnish a more favourable result than the above, but are, nevertheless, sufficient to excite the gravest foreboding; commencing, as they do, with myopia of 3.55 per cent., and rising to 26.79 per cent.